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AUTHOR	Chapline, Elaine B.
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ABSTRACT

The Teacher Education and Mathematics (TEAM) Program has been developed to reduce mathematics anxiety and increase mathematics confidence and competence of teacher education students; to increase their perception of mathematics as female domain; and to develop their skills in identifying sex bias in curriculum materials and classroom practices. The project has aimed to produce a qualitative change in the teaching of mathematics and ultimately in the resulting educational experiences of children in the critical area of mathematics. Five mathematics modules, which include suggestions on both mathematics instruction and attitude development, are: Number Patterns, Approximation and Estimation, Metric Measurement, Choice and Chance, and Space. Additional attitudinal modules are: Demystifying Math, Sex-role Stereotyping in Mathematics, and Women and Mathematics. The summative evaluation data indicate that the program materials effectively reduced mathematics anxiety scores from pre- to posttest for a majority (77%) of students during pilot testing and for a majority (87%) during field testing. Questionnaire and interview data reveal increases in students' awareness of sex-role stereotyping in mathematics. Students indicated that they knew strategies for counteracting sex bias which they could use in their future work as teachers. (Author/MK)

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TEACHER EDUCATION AND MATHEMATICS: PROGRAM DEVELOPMENT AND EVALUATION*

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ELAINE B. CHAPLINE

QUEENS COLLEGE OF

THE CITY UNIVERSITY OF NEW YORK

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INTRODUCTION

The project on Teacher Education and Mathematics (TEAM) is designed to effect a qualitative change in the teaching of mathematics and the resulting educational experiences of children in the critical area of mathematics. Mathematics is a key area of the curriculum, often identified as fulfilling a gatekeeping or filtering function because of its importance in many careers: "The educational and occupational opportunities of most women are severely restricted by inadequate preparation in mathematics..."(Kreinberg, 1976) and a recent analysis of the longitudinal data in the Project Talent data bank adds to prior findings that sex differences in performance in mathematics are accounted for by the number of math courses taken by men and women -- women continue to take fewer courses in mathematics and to limit their career choices as a result (Burton, 1979; Wise, 1978).

Sex differences in mathematical experience and the patterns of math avoidance among females must be changed. Math anxiety and sex-role stereotyping of mathematics as a male domain have frequently been cited as factors in math avoidance (Tobias, 1976; Fennema and Sherman, 1977). Fox (1976) has stated this view: "Although anxiety about mathematics may not in every case be a direct result of sex-role socialization conflicts, it is likely that the sex-typing of mathematics as a male domain by parents, teachers and peers results in the acceptance of math-anxiety in females as inevitable or irrelevant to their development" (p.49).

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Anecdotal records of counseling sessions with math-anxious professional women suggest that math anxiety can occur early in the elementary school years (Donady, Kogelman, and Tobias, 1976). Teachers' attitudes, classroom activities, and sex-role stereotyping in materials have all served to reinforce the perception of mathematics as a male domain (Brophy and Good, 1970; Fennema, 1980). Donady and Tobias (1977) have pointed out the need for teachers who are free of math anxiety so that they can help their students enjoy mathematics and continue to study mathematics. Skypek (1980) stressed the important role of elementary school mathematics curricula and practices in children's learning sex roles and suggested that these practices lead to discriminatory, differential expectations for females and males. Teacher educators have a responsibility to face these issues and to inform prospective teachers about inequities in mathematics education.

The project on Teacher Education and Mathematics (TEAM) is designed to prepare elementary school teachers to be aware of the importance of mathematics for girls by developing a model program and instructional materials that can be used in undergraduate teacher education courses in a variety of settings. More specifically, the program and materials are designed: to reduce mathematics anxiety in teacher education students; to increase their perception of mathematics as a female domain; and to develop their skills in identifying sex bias in mathematics curriculum materials and teacher-pupil interaction in the classroom.

THE TEAM PROGRAM AND MATERIALS

Instructional strategies are designed by Dr. Claire Newman, Mathematics Educator and by the author, both to foster positive attitudes toward math and to develop mathematical knowledge and skills. The inverse relationship between math knowledge and math anxiety reported in the literature (Aiken 1970, 1976; Richardson and Suinn 1972, 1973) provided the rationale for this program which seeks to integrate cognitive and affective learning opportunities in mathematics.

During the materials development, pilot testing and initial field testing stages of the project, teaching was carried out by a mathematics educator and psychologist teaching team (both women) who sought to develop a non-threatening, responsive and stimulating classroom environment. Math materials focused on concepts and problem-solving processes. Calculators, considered daily equipment in contemporary society, were used during class sessions. Materials which deal specifically with the impact of sex-role stereotyping in mathematics learning are incorporated in the program.

Five mathematics topics were selected and developed into modules: (1) Number Patterns, (2) Approximation and Estimation, (3) Metric Measurement, (4) Choice and Chance and (5) Space. These were chosen on the basis of several criteria. It was judged important that these math modules relate directly to the Basic Mathematical Skills areas promulgated by the National Council of Supervisors of Mathematics (NCSM). Topics were selected that, because of their high interest appeal, had a high potential for student participation. They were deemed feasible for production and did not duplicate existing materials. In addition, the topics were based on the needs of the target population as perceived by teacher educators and the knowledge requirements for elementary school teachers as given in a sample State mathematics syllabus. Other considerations included national trends in mathematics education, such as the use of calculators and metric measurement.

Each math module consists of an Instructor's Text, Student Materials, Solutions and Guide for the Use of Student Materials, Student Notes (or text), Skill Objectives and Evaluation Materials. The Instructor's Text directs the instructor on what to do and how to do it, and provides commentary which includes

explanations, instructional options, attitudinal interventions and organizational interventions.

In addition to the math modules, there are modules specifically designed to deal with students' attitudes. The first of these is Demystifying Math in which math autobiographical experiences, math myths which serve as learning barriers and math in daily life are considered. The second is Sex-role Stereotyping in Mathematics, in which students learn to identify sex-bias in curriculum materials and classroom practices. Third, Women and Mathematics in which the significance of math in careers, and women's contribution to the discipline of mathematics are considered.

Throughout the pilot testing of the materials, observational data were collected at every session by at least two observers. The frequencies of student responses were tabulated, and apparent anxiety-produced reactions were classified and rated as to intensity. Periodically, students were asked to rate the session they had just completed. In addition, extensive recordings of both the mathematical content and attitudinal topics were undertaken. The purpose of these activities was the revision and improvement of the materials.

EVALUATION DESIGN AND INSTRUMENTATION

Changes in students' mathematics anxiety, math confidence and perceptions of math's usefulness were assessed by pre and post design. Scores on Mathematics Anxiety Rating Scale (MARS), (Suinn and Richardson), and the Confidence and Usefulness sub-scales of the Fennema-Sherman Attitudes Toward Mathematics Scale (1976) were used in these comparisons. Interviews or questionnaires, used pre and post, provided data on students' background in math experiences, factors which influenced attitudes, knowledge of sex-role stereotypes and women's contributions to mathematics. Math achievement was assessed by using a Mathematics Concept Test, by module-related quizzes and by a final examination.

PILOT TESTING OF MATERIALS

The experimental group (n=44) was taught by the program developers in the spring semester 1979 in a.m. and p.m. sections which met for 14 three-hour sessions. The class consisted of female college juniors who had largely not taken math since high school, who reported negative experiences and feelings about math and who wanted to increase their achievement and confidence in working with mathematics. Their math anxiety was greater and their math confidence lower than that of a comparison group of teacher education students (n=51). This experimental group also perceived math as less useful than did the comparison group. These mean pretest differences were significant beyond the p.01 level. (see Table 1)

Table 1 Means and Standard Deviations of Attitude Measures for the Experimental and Comparison Groups (pretest scores)

Attitude Measure	Experimental group M	SD	range	Comparison group M	SD	range	t	p
MARS	245.3	64.7	109-371	209.1	65.0	104-404	2.71	.008
F-S Math Usefulness*	34.8	6.3	23-46	38.8	5.0	28-48	3.39	.001
F-S Math Confidence*	20.5	9.6	3-39	29.3	10.0	4-48	4.33	.000
	n=44			n=51				

*Higher scores indicate increased confidence and perception of math's usefulness.

During the semester, students rated class sessions periodically, using a five point scale, on whether sessions were: interesting, useful, new, understandable, frightening, easy, hard, long or short. In general, while the p.m. class was a bit more enthusiastic about their learning experiences, both groups provided positive ratings of the materials and classroom environment. Students' comments were used in revising materials, e.g., shortening or expanding a content section, planning for subgrouping to provide for differences in

achievement levels, stressing the relationship of a math concept to a contemporary world event or situation, and so on.

Observations of class sessions yielded a particularly intriguing bit of student behavior. When the psychologist began to work with the a.m. class on preparing for their first math quiz, three students took hair brushes, nail files or lipsticks from their purses and began to groom themselves during the discussion of the upcoming quiz. The staff ventured the interpretation that this behavior was related to the conflict which these young women experienced in the face of math plus test anxiety. Their retreat to stereotyped femininity suggests a good deal about their socialization.

The experimental group's posttest means on anxiety, confidence and usefulness all showed substantial progress in the desired direction. Correlated *t* tests revealed differences significant beyond the .01 level. (see Table 2)

Table 2 Means, Standard Deviations, and *t* tests for Pretest-Posttest Attitude Scores of the Experimental Group (n=44)

	Pretest scores		Posttest scores		*t* (correlated)	*p*
	M	SD	M	SD		
MARS	245.3	64.7	211.6	64.6	4.26	.001
F-S USEFULNESS *	34.8	6.3	38.1	5.7	3.69	.001
F-S CONFIDENCE *	20.5	9.6	26.4	9.3	5.86	.001

*Higher scores indicate increased confidence and perception of math's usefulness.

The decrease in anxiety scores for the experimental group brought these students who had concerns about mathematics to the level of students who were not recruited as math anxious students. Similarly, the changes in the Confidence and Usefulness scores indicated student increases in perceptions of mathematics as useful and

an increase in their own confidence in mathematics. (see Table 3)

Table 3 Means, Standard Deviations, and t tests for Experimental group (Posttest scores) and Comparison Group on Attitude and Achievement Measures.

Measure	Experimental group Posttest scores M	SD	Comparison group M	SD	t	p
MARS	211.6	64.6	209.1	65.0	.19	N.S.
F-S Usefulness *	38.1	5.7	38.8	5.0	.59	N.S.
F-S Confidence *	26.4	9.3	29.3	10.0	1.43	N.S.
Math Concepts	25.3	7.7	24.7	7.8	.38	N.S.
	n=44		n=51			

*Higher scores indicate increased confidence and perception of math's usefulness.

Knowledge was assessed on four measures during the semester. Two module related quizzes were administered, a final examination and a math concepts test to examine the generalizability of the increased knowledge.

The quizzes and the final examination indicate substantial knowledge gains if the assumption of little or no incoming knowledge is accepted. Pretests were not administered because of the liklihood of reactive effect.

The final examination assessed information and knowledge from all previous lessons. A considerable range of scores was evident (26 to 100) but, over half the students received scores of 85 or better, an indication of knowledge gains.

In addition, a math concepts test was developed and administered in a posttest-only design. The means for the experimental and comparison group do not differ. This concept was revised in summer 1979 to reflect more adequate coverage of the content of the mathematics modules. This revised test has been used now in a pretest-posttest design during field testing.

End-of-course interviews provided substantial evidence of students' developing more positive attitudes toward math. (78% reported more positive attitudes toward math). On self-ratings of anxiety, 61% indicated that they were less anxious, and 59% indicated that they had gained some insight about the source of their anxiety.

Several questions on the final interview were related to the effects of the instruction about sex-role stereotyping, the importance of mathematics for women, and the importance of teacher's attitude toward mathematics. Responses suggest that the material and ideas were new to these students. For example, responses to the manner in which females are treated in math texts were coded into four categories, three of which indicated dissatisfaction with the treatment of females. Only three students (7%) stated the treatment of females was not so bad. Samples of the types of statements in the other three categories were:

> "I think it is disgusting. Now I can see why women feel the way they do about math. It starts at such a young age, the sex-bias, that it is easy to see the women's attitude toward math."
>
> "I think it is horrendous. It has a long-term effect on their attitudes toward themselves as people and on their potential in the world of mathematics."
>
> "Unfairly shown as nurses, teachers. Wasn't aware of it until we examined math texts---really a revelation. Young years are very impressionable and important. Teachers have a great deal of influence at that time."
>
> "I can't believe it. They make the woman feel that men can do it and women cannot. I see it in magazines, TV, and so on."
>
> "Never noticed it before---new books seem to be free of sex-bias."
>
> "I felt females are treated in a subordinate manner. Makes me feel sad. I have to be twice on guard. Examples in books were not blatant but rather subtle."
>
> "That surprised me a lot; I never was aware before and I didn't notice it in elementary school. It is demeaning to girls; it is a shame. I wonder if young kids notice it."
>
> "Stereotyped! Boys always seem to go fishing and they catch five fish. Peggy Sue goes to a party and she breaks three balloons. The boys are named Bobby and the girls Peggy Sue. If I don't get a job teaching, I'm going to rewrite the textbooks."

On their final examination, all students were able to describe a variety of strategies that they could use as teachers to counteract the effects of sex bias in mathematics instruction.

FIELD TESTING OF MATERIALS

Field testing groups A and B were taught by two mathematics educator-psychologist teams who were briefed by the program developers. These two classes each of which met for 15 sessions in fall 1979 consisted of a total of 33 students. More than half of the students were juniors, and thirty of them were female. About half were Black and Hispanic, and half white. In general, they reported more negative than positive attitudes toward experiences in math. Their mean math anxiety score (252.9) was similar to that of TEAM I students at the beginning of the program, their math confidence was slightly lower and their perception of math's usefulness higher. Their mean score on the math concepts test was 19.3 out of a possible score of 36.

During the semester, the process evaluation strategies developed for TEAM I were used to provide student feedback on the materials and learning activities. Their comments and suggestions proved useful and were considered in material revisions. Summative evaluation data were reused.

Initial analysis of the groups' pre to posttest means on anxiety, confidence and usefulness all showed substantial progress toward program goals. The anxiety posttest mean (195.8) was less than that of the TEAM I group, the comparison group, and the norm groups reported by Suinn and Richardson.

The groups' math knowledge and skills, i.e., differences in pre to posttest means, showed gains (20.8 on pre to 29.3 on post for 36 items at School B and 4.9 on pre to 6.6 on post for 10 items at School A).

End of course questionnaires provided evidence of students developing more positive attitudes toward math; 84% reported substantially

more positive attitudes. In self-report anxiety ratings, 72% of the group reported little or moderate and 21% reported no anxiety about math. Students reported more positive reactions to daily math situations. Over 70% of the group reported such feelings as more curiosity and more confidence. Seventy-three percent reported using math more frequently. Projecting ahead to teaching, over 70% of those who are planning to teach reported expecting to feel confident and comfortable about teaching math.

The students considered the best things about the course to be increasing personal math confidence, learning difficult content areas, and succeeding on math tests. They commented favorably on the classes' friendly, honest and relaxing atmosphere. They felt that they were able to express their attitudes and opinions. They considered the worst things about the class to be particularly difficult content topics and the length of class sessions. Almost 30% said nothing was wrong with the course, and 90% suggested that the course be given on a regular or permanent basis.

It seems reasonable to conclude based upon pilot and field test experiences that prospective teachers' mathematics skills and attitudes, and awareness of sex bias can be positively influenced by using TEAM materials.

SUMMARY

The Teacher Education and Mathematics program has been developed to reduce math anxiety of teacher education students; to increase their perception of mathematics as a female domain; and to develop their skills in identifying sex bias in math curriculum materials and classroom practices. Using formative evaluation data gathered during pilot testing, mathematics and attitudinal modules have been revised and field tested. The summative evaluation data indicate that the program materials effectively reduced math

anxiety scores from pre to posttest for a majority (77%) of students during pilot testing and for a majority (87%) during field testing. Questionnaire and interview data reveal increases in students' awareness of sex-role stereotyping in mathematics. Students indicated that they knew strategies for counteracting sex bias which they could use in their future work as teachers. This program appears to have utility in dealing with this key sex-equity issue.

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